DOCUMENT RESUME

ED 184 050 CS 005 071

AUTHOR McConkie, George W.
TITLE Eye Movement Monitoring in the Study of Silent Reading.
PUB DATE Apr 79
NOTE 9p.; Paper presented at the Annual Meeting of the American Educational Research Association (San Francisco, CA, April 8-12, 1979). For related documents see CS 005 071-072 and CS 005 321-323.

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Computers; *Eye Fixations; *Eye Movements; Measurement; *Measurement Techniques; *Reading Processes; *Reading Research; Research Methodology

ABSTRACT

Eye movement monitoring is useful both in the control of experiments on reading and as a source of data. Experiments using eye monitoring techniques have helped develop the following conclusions about the reading process: the region of text read during a fixation is quite small and asymmetric to the right of the center of vision, successive fixations are essentially nonoverlapping, the durations of fixations reflect cognitive processing occurring at that point in the text, and the eye is directed to specific locations in the text during reading. To continue exploring the reading process with eye movement techniques, a monitoring system was developed and tested using a Biometrics eye movement monitor connected to a PDP-11/40 computer. As the eye monitor reported eye positions 1,000 times per second, the computer controlled text display on a cathode ray tube (CRT) and recorded all data for analysis. Printouts of the data showed how eyes moved across a line of text, eye fixations and their lengths, movements between fixations, and changes in text display. Since the computer can be programed to make adjustments in the text display while eye movements are in progress, it provides greater control over experimental data and a faster means of verifying and refining previous research. (RL)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
George W. McConkie
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

ED184050

CS205071

Eye Movement Monitoring in the Study of Silent Reading[1]

George W. McConkie
Center for the Study of Reading
University of Illinois

As the title of this session indicates, the studies to be reported here dealt with various questions about the perceptual and language processes taking place during silent reading, and they investigated these questions using techniques which involved the monitoring of the readers' eye movements. Thus we hope that this session will be useful both by providing examples of eye-movement based reading research, and by providing information about the nature of reading.

It has been our desire to study reading as it is in process. This is difficult to do because while we may believe that the mental activities occurring are rich and complex, there are few outwardly observable indicators of these activities as reading is taking place. Eye movements are, of course, one of these. While we would agree that past decades of research on eye movements in reading have not been particularly helpful in understanding the nature of reading, this situation appears to be changing. Today, research techniques involving eye movements are contributing significantly to our understanding of the reading processes, and this contribution is likely to increase in the future. We hope that the studies to be described today will illustrate the potential of this approach to reading research.

Eye movement recording is useful to the researcher in two different ways. First, in order to study reading as it is taking place, we must know what is being read at any moment in time. This problem can be illustrated by looking at studies of comprehension of oral language. Here the presentation of the stimulus is under the experimenter's control. We can control approximately when a given part of the auditory signal will strike the listener's ear. We recognize some indeterminacy in knowing just when a phoneme begins and ends, or when a word can be said to have been perceived. Still, there is sufficient access to and control over the stimulus presentation to permit the experimenter to place a click at a specific location in the speech stream, or to measure a response time from the approximate occurrance of a particular phoneme. Knowing when specific aspects of the stimulus are encountered provides a basis for both making manipulations and making measurements with respect to certain aspects of the stimulus, in order to study language processing.

In reading, however, the text is physically present at all times, and the sequence and timing of its being encountered is under the reader's own control. Thus, it becomes more difficult to know exactly when a particular letter or word is being encountered, in order to make manipulations or measurements with respect to it. Our most likely candidate for providing that information is the eye movement record.

However, there are some serious problems in using eye movement records for this purpose. While these records indicate the location, duration and sequence of fixations, they do not by themselves indicate what region of the text was being seen during any one of the fixations, when during the

fixation a given part of the text was being encountered, or how long following its encounter it was understood at some level. These are questions needing careful research before the full potential of eye movement monitoring for experimental control purposes can be realized.

The second use of eye movement monitoring is as a source of data. More and more evidence is accumulating to indicate that where the eye is sent and how long it remains at each location is specifically controlled and reflects various aspects of the mental activities of the reader (Rayner, in press; Levy-Shoen & O'Regan, in press). Questions about perceptual and language processing during reading can be answered using such detailed aspects of eye movement data as the mean duration of fixations in specific locations in the text, just where the eye is sent on saccades in certain textual regions, and the number and characteristics of regressive movements in particular places. It must be recognized that the problems mentioned earlier also arise in interpreting eye movement records as data. The eye movement record by itself does not indicate on which fixation a given word was perceived, nor when textual relations involving information from that word were realized. Thus it is often difficult to know just what data to select to test a particular hypothesis. Again, basic research is needed.

In summary, eye movement monitoring is useful both in the control of experiments on reading, and as a source of data. However, substantial research is still needed before these potential uses will be fully realized.

During the last several years we have conducted a series of studies investigating various questions about the perceptual processing involved in silent reading. I will briefly review a few of the conclusions from some of these studies.

1. The region of text which is read during a fixation is quite small and asymetric to the right of the center of vision. For instance, reading is not affected when, during each fixation, all letters more than 4 letter positions to the left of the fixation point are replaced by other letters. Similar replacement to the right of the fixation point is highly disruptive to reading (McConkie & Rayner, 1976). My guess at the present time is that the region of text which is read during a fixation may not be much larger, if any, than the length of the saccade, thus averaging around 8-10 letter positions for skilled readers (McConkie, in press).

2. Any particular letter is typically "seen" by the reader on only a single fixation unless a regression is made back into an area previously read. Thus, perceptual spans from successive fixations are essentially non-overlapping. For instance, pairs of words can be identified which differ in only a single letter, such as brain and brawn. Sentences can then be written in which either word of the pair is appropriate. As subjects read such a sentence from a Cathode-ray Tube the contents of that critical letter position can be switched during each saccade, so the word in that location is brain on one fixation, brawn on the next, brain on the next, etc. In this situation, subjects are totally unaware that any change is occurring, and readily report one of the two words as having been in the sentence. Nor does the change have any influence on eye movement patterns. Thus it appears that a letter acquired during one fixation is not being seen during the next (McConkie, 1978).

3. The durations of fixations reflect cognitive processing occurring at that point in the text. In one pilot study, synonym pairs were identified,

one being high in cultural frequency and one being low, both having the same number of letters. Fixations on those words were 20 msec. longer when the low frequency word was in the text than when the high frequency word was. Other studies to be reported in this session will bear on this issue, also.

4. The eye is being sent to specific locations in the text during reading. In another study, during certain saccades the text was physically shifted 2 letter positions to the left or right on the CRT, causing the next fixation to be centered at a slightly different place in the text than would normally have been the case. Subjects were unaware that any change had taken place, but their eye movements were definitely affected. A shift to the left caused a large number of short leftward saccades, about 2-3 letter positions in length. A shift to the right cut the normal number of regressive movements in half, but did not produce short compensatory movements. Thus, when the eye stopped in a textual location other than that to which it was initially sent, definite changes in eye movement behavior resulted.

The studies to be reported here today continue our exploration of reading processes using eye movement techniques.

In these studies eye tracking was done with a Biometrics eye movement monitor, interfaced to a PDP-11/40 computer. This computer also controlled the text display on a Cathode-ray tube. The text was presented one line at a time with only the horizontal component of the eye movements being monitored. Subjects pressed a button to bring the next line of text onto

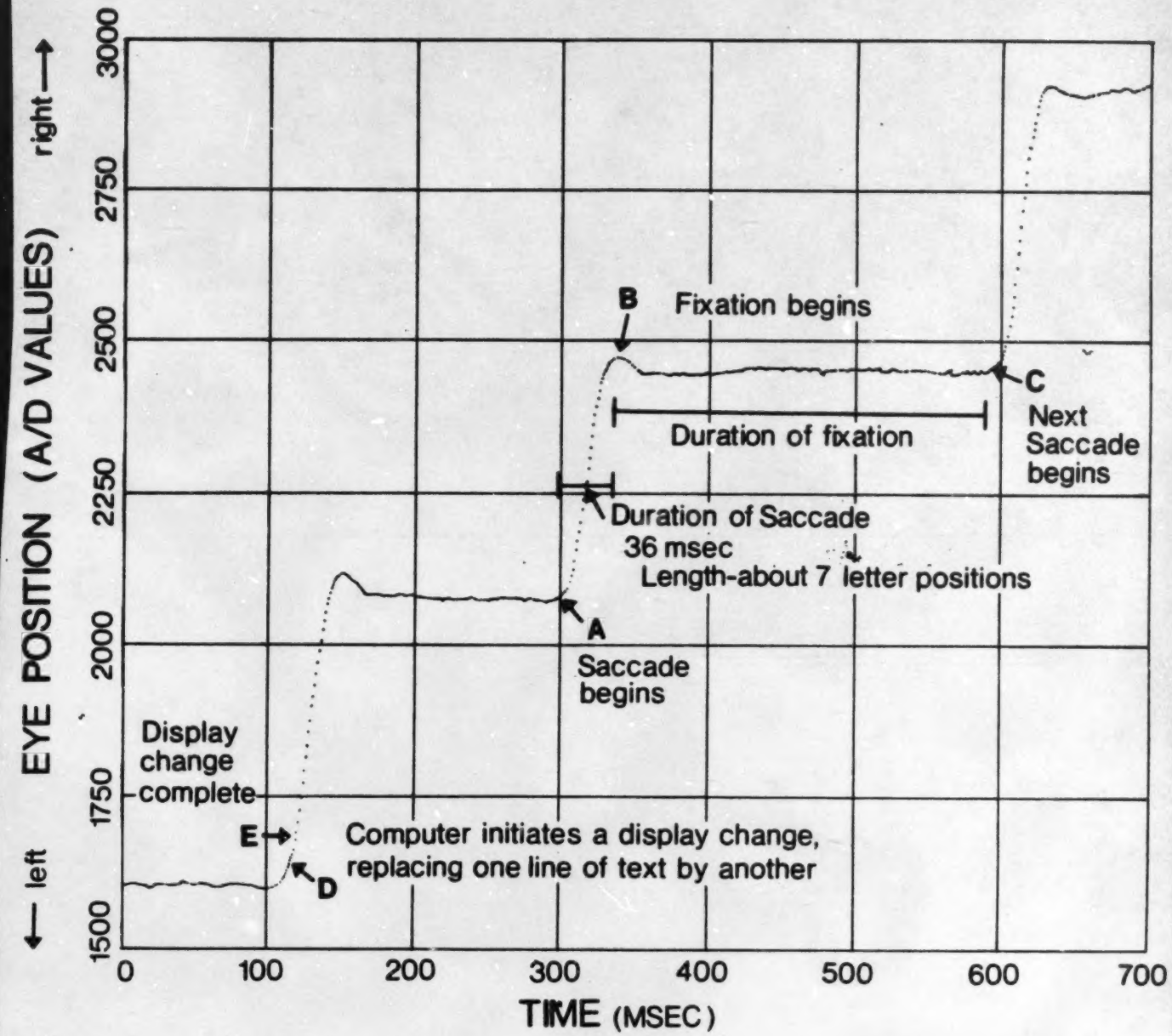
the screen, which happened within less than 1/10 second. Hence they were able to read extended passages without difficulty. The reader's eye position was sampled every msec., that is, 1000 times per second.

Figure 1 on Page 2 of the handout provides an example of these data. Here, time in msec. is represented on the X axis, and eye position on the Y axis. A flat portion of the curve, as shown beginning at point B, indicates a period of time when the eye was in a fixation, or relatively still. Point C indicates the point at which a saccade was initiated; the rising curve indicates an eye movement in progress taking the eye to a new location. The D indicates the point at which the computer was certain that an eye movement was underway and a change in the display was initiated at that time. The E indicates the point at which this change had been completed and written on the CRT. Since the change of a line can be made within about 3 msec, display changes can be produced very rapidly at a specific time during a saccade or fixation, as desired.

The computer system which has been developed for conducting these types of studies and for analyzing the data is described in greater detail in a recent article in Behavior Research Methods and Instrumentation.

Footnote

[1]This paper was presented as part of a symposium entitled "Eye Movement Monitoring in the Study of Silent Reading" at the 1979 meeting of the American Educational Research Association in San Francisco, California. Research mentioned in this paper was partially supported by Grants No MH24241 and MH32884 from the National Institute of Mental Health.


← left EYE POSITION (A/D VALUES) right →
3000
2750
2500
2250
2000
1750
1500
0
100
200
300
400
500
600
700
TIME (MSEC)
B
Fixation begins
C
Next Saccade begins
Duration of fixation
Duration of Saccade
36 msec
Length-about 7 letter positions
A
Saccade begins
Display change complete
E
D
Computer initiates a display change, replacing one line of text by another